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13. ABSTRACT *(Maximum 200 words)*

The Laser Doppler Vibrometer (LDV) optical instrument purchased under the DURIP grant is used for accurately measuring velocity (and displacement) of vibrating surfaces completely without contact. It is a complete, self-contained area vibration measurement and analysis system. The LDV automatically collects complete vibration data from up to thousands of individual points on a user-defined area. An important feature in scanning vibrometers is the ability to validate and improve the quality of measured data at every scan point. This overcomes problems caused by dark speckles and other unavoidable phenomena present in laser vibrometry. The system purchased is also equipped with Live and Fully Integrated Video Imaging. The equipment is particularly useful at higher frequencies (above Skit) where accelerometers become increasingly inaccurate due to their own dynamic characteristics and influences. A large number of applications that require measurements at very high frequencies and cannot be accomplished using accelerometers include piezoelectric transducers and exciters, NDE flaw detection, rotor blades, disk drive components and micro-sensors and actuators.

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Experimental Investigation in Vibration Control and Damage Detection of Smart Composites

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Grant Number: F49620-00-1-0246
Technical Monitor: Dr. Daniel Segalman

Description of Equipment Purchased

Polytec PI PSV-300-F VibraScan System, Price: $180,050. Expected life: 10 years.

Following is a detailed description of the Vibrometer and associated software.

VibraScan PSV-300-F

Item	Part #	Description	Price
1.	PSV-300-F	**High Performance Scanning Vibrometer:** PSV-300-F part number & price includes the following components (1.1.1 through 1.2.3):	$ 149,950
1.1.1	OFV-3001-SF6	Scanning Vibrometer Controller; high frequency version,	
1.1.2	OFV-056	High-performance scan head	
1.1.3	OFV-303	Laser sensor head	
1.1.4	PSV-Z-040-F	Junction box	
1.1.5	PSV-PC-F	Data Analysis & Management system:	
1.1.6	PSV-C-10	Single umbilical heavy duty interconnecting cable	
1.2	PSV-300-F-S	Software package for PSV-300-F based scanning Vibrometers,	
1.2.1	PSVSOFT-F	Software for two channel data acquisition system	
1.2.2	PSV-Z-067	Fast Scan	
1.2.3	PSV-Z-073	Gate Input,	
2.	PSV-Z-061	Universal File Format (UFF) converter	$5,950
3.	PSV-Z-062	APS (Advanced Point Scan) Selection software	$3,950
4.	PSV-Z-GEN-H	Hardware & Software for control arbitrary waveform generator	$2,950
5.	PSV300-SM-12	One-year software maintenance.	$4,800
6.	PSV-Modal	Modal analysis software	$10,200
7.	PSV-TTT-1	On-site training for the PSV-300	$1,500
8.	PSV-T	Tripod	$750
		Total	**$180,050**

Additional equipment purchased using cost share from Arizona State University is listed below.

MT P-14 Programmable Hydraulic Press

RS4000-48-12 Vibration Tabletop with Tuned Damping

I-2000-428 Stabilizer Vibration Isolators

Various Accessories for Vibration Testing Equipment

2100 TN Hewlett Packard LaserJet Printer

The total amount of funds received from AFOSR was $178,599. ASU provided $50,000 as cost share.

Description of Research Conducted

The Laser Doppler Vibrometer (LDV) optical instrument is used for accurately measuring velocity (and displacement) of vibrating surfaces completely without contact. It is a complete, self-contained area vibration measurement and analysis system. The LDV automatically collects complete vibration data from up to thousands of individual points on a user-defined area. An important feature in scanning vibrometers is the ability to validate and improve the quality of measured data at every scan point. This overcomes problems caused by dark speckles and other unavoidable phenomena present in laser vibrometry. The system purchased is also equipped with Live and Fully Integrated Video Imaging. The equipment is particularly useful at higher frequencies (above 5kHz) where accelerometers become increasingly inaccurate due to their own dynamic characteristics and influences. A large number of applications that require measurements at very high frequencies and cannot be accomplished using accelerometers include piezoelectric transducers and exciters, NDE flaw detection, rotor blades, disk drive components and micro-sensors and actuators.

Experiments are conducted in support of the delamination characterization study and to validate the modeling methods used to determine the effects of delaminations on composite laminates. The first set of experiments was for validation of the higher-order theory for modeling smart composite structures in the presence of delaminations. Graphite/Epoxy composite specimens are constructed using the hot press. ACX Quick Pack actuators are surface bonded to the plates. The scanning laser vibrometer is used to verify the modeling methods by experimentally analyzing the response of the test structures. The results are compared to those obtained from the developed theory. The scanning laser vibrometer can actuate the structure at

specific frequencies and measure the out-of-plane velocity and displacement at discrete points across the surface of a plate structure. Points can be chosen with sufficient density to create a smooth continuous distribution of displacement across the surface. Using the displacement, the strain across the surface can be calculated for any given frequency. Since the velocity resolution of the scanning vibrometer is 0.3 μm/s, the resulting displacements and strains have a high level of accuracy necessary for capturing the influence of damage on structural response. The scanning vibrometer also has the advantage that information is easily gathered for the entire structural surface, unlike strain gages, which limit results to a few discrete points. This allows a large amount of information to be gathered quickly during experiments making them less costly and time consuming.

The second set of experiments is in support of damage detection methods. Experiments are conducted to support the characterization studies and to obtain more physical insight into issues such as interaction between multiple delaminations and structural response. Comparisons are made between model predictions (damage indices, previously developed) and the results measured using the scanning laser vibrometer and strain gages. The dynamic response of healthy specimens with surface bonded sensors as well as composite specimens with localized damage in the form of delamination are studied. The experimental set-up is depicted in Fig. 1.

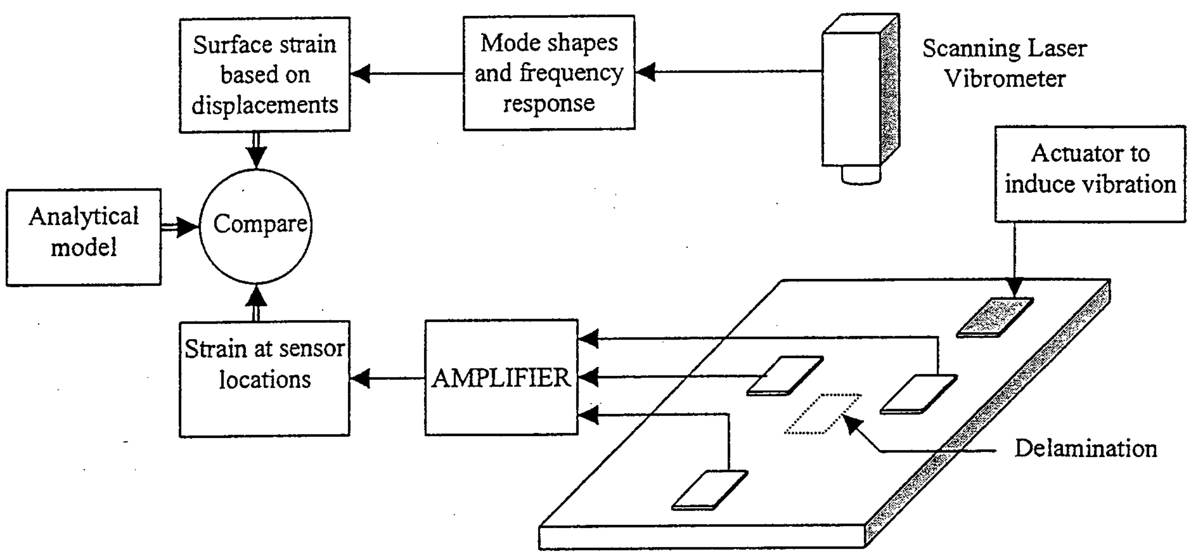

Fig 1. Experimental setup for verification for sensor output and analytical model.